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Healthier Sugar: Possibilities and Future Prospects

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***Abstract*— Many food processing industries have witnessed a measurable change in the demand and supply of various products in the market due to changing consumer preferences and market demand. In an effort to "Stay Fit" and being calorie conscious, sometime the consumer fails to recognize the nutritional value of product and its importance for health. Due to this and because of large number of families in developing and under developed countries been below poverty-line, under-nutrition and micronutrient deficiencies are often observed affecting public health. As sugar being one of the staple food, consumed by almost every individual and India being one the largest producer and consumer of sugar, enriching sugar with micronutrients may a promising approach to overcome the controversies which have arisen about sugar over the last few years and to provide so termed "Healthier Sugar". This approach would not only help the sugar sector to diversify its resources for value-addition but would also help in providing the required micronutrients to the common masses so as to fulfil their RDA (recommended dietary allowance) which otherwise is not met through normal diet.**

Keywords*— *Nutritional, calories, sugar, RDA, fortification, micronutrients

I. INTRODUCTION

The term malnutrition broadly covers over-nutrition, under-nutrition and micronutrient deficiencies characterized by higher or lower levels of macro or micronutrients or both in human diet. On the one hand numerous obese and over-weight cases are recorded worldwide as a result of over nutrition (WHO 2009), on the other hand under-nutrition and micronutrient deficiencies are sporadic thereby significantly affecting public health. Micronutrient deficiency is of major concern in developing or underdeveloped countries especially amongst lower income group with poor accessibility to nutritious diet. Among all micronutrient, the main forms of micronutrient deficiency seen includes vitamin A, iron or iodine, folic acid, vitamin D, selenium and zinc. Inadequate quantities of these micronutrients severely affect health and development of individuals particularly children and pregnant women thereby accounting for 7.3% of the global burden of disease (IFPRI 2016).

Having a controlled and balanced intake of essential nutrients and minerals is an integral part of the overall effort to fight and eliminate the 'hidden hunger' and malnutrition prevalence in any country. Several policies and other food-based initiatives may be diversification of dietary patterns, nutritional education as well as food fortification, food safety measures and last but not the least, supplementation. Of all these strategies, which primarily aim at increasing the micronutrient intake, micronutrient supplements provide a quick access of nutrients thus improving the nutritional state of the targeted population. But it is often seen that these supplements incur extra burden on the dietary habits of an individual and may not seem to be that promising in controlling micronutrient deficiency, especially for the lower income groups as they might not be able to afford such supplements. On the other hand, dietary diversity is often regarded as one of the most effective and suitable option for improving micronutrient deficiency but it takes long for its impact to be sustainable. Also the availability and consumption of, the access to various forms of micronutrient-rich foods in adequate quantity, specifically to the target group (who are at greater risk or are vulnerable to micronutrient malnutrition) delays the effectiveness of the programme (The World Bank 2013).

While sustainable development goal tag 'End all Forms of Malnutrition' by 2030, of the 7 billion world population, around 2 billion people worldwide are suffering from micronutrient deficiencies (Ezzati et al., 2004). Mostly developing countries including India are in the clutches of micronutrient malnutrition. As it is said that Indian diets are awfully rich in staples, but the fact is that mostly the diets are rich in calories and hardly provide any nourishment. While on one hand, running out of food or food scarcity results in persistent hunger, on the other hand vitamin and mineral deficiency takes the shape of 'hidden hunger' that often goes un-attended. This hidden hunger has greater consequences in a long run as it leads to poor mental and physical well-being of an individual, reduced or impaired IQ, increased susceptibility to disease and infection, increased rate of mortality (both among children and pregnant women) as well as reduced cognitive development. For instance, insufficient folic acid during first few weeks of pregnancy increases the risk of serious birth defects. Vitamin A deficiency has also affected millions of children and women with night blindness while also compromising their immunity (Akhtar et. al., 2013) (NSSO report 2011).

Across the globe, the world has seen the huge scope, food fortification holds promise in improving the nutritional profile of the country. Food fortification has a long history to be used in industrialized countries for controlling deficiencies of vitamin A, D, so on and so forth.

Multiple micronutrient deficiencies are rampant in India, and continue to be significant public health problems, which adversely impact the health and productivity of all the population groups. More than 57% of children suffer from vitamin A deficiency, which may be symptomatic or present at the sub-clinical level. In addition, a high proportion of

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pregnant women and their new-borns suffer from Vitamin D deficiency.

Sugar being an essential commodity can be considered an excellent carrier for these micronutrients to tackle the issue of deficiency. In fact, considering the fact that sugar is being tagged as culprit for many health issues, raw sugar (more appropriate to term as natural cane sugar) may also be fortified with such micronutrients and then may be considered for sale in the open market or specifically to economically weaker sections of the society.

II. FOOD FORTIFICATION IN INDIA

As per the Food Safety & Standards Authority of India (FSSAI) guidelines and recommendations for India, 5 food staples namely double fortified salt, milk, edible oil, flour and rice are being fortified with essential nutrients with a view to reduce and eliminate vitamin and mineral deficiencies so as to improve the overall health status of masses as well as to sustain economic growth and development of the nation as a whole.

In India, food fortification goes way back to 1950s where initially fortification of Vanaspati with vitamin A was mandatory and the same complies to the present time as well. Similarly, universal salt fortification with iodine came into light in 2005. The sale of non-iodised salt for human consumption was restrained both at national and state level.

Salt Fortification

Amongst all countries across the globe, India was the first country in Asia to initiate public health programme in order to address iodine deficiency disorder with the help of salt iodisation. With the advent in technology, increased availability of fortified salt (iodised salt), consumer favourable packaging, efficient monitoring, increased consumer awareness, fortified salt processing and acceptability has reached to desired levels.

The results of double fortified salt in improving anaemia and iron deficiencies were quite evident. Double fortified salt (DFS) led to appreciable improvement in haemoglobin, ferritin, soluble transferrin receptors and body iron among female Indian tea pickers over a period of about 9 months (Has Jere D. et. Al., 2014). The double fortified salt (DFS) could reach to the most vulnerable group of children with the help of mid-day-meal programmes.

Wheat Fortification

Wheat is among the second most consumed staple food next to rice with around 50 kg/year per capita consumption in India. Major calorie intake of the Indian diets is contributed by this cereal (NCAER 2015). In 2006 Gujarat introduced around 604,000 MT of fortified wheat flour into their social safety net programme, which increased the sales of roll mill flour and chakkis (local small scale milling units) by 43% (Fiedler et. Al., 2012). Such initiatives of distribution of fortified wheat flour through government channels has significantly contributed towards reduction of anaemia.

Rice Fortification

As per USDA estimates, India remains at no.2 position as far as rice production is concerned during the year 2022-23 with a possible production of 126.5 MMT, while China to remain at the top position with estimated rice production of 147.0 MMT. Fortifying rice makes it more nutritious by adding vitamins and minerals in the post - harvest phase; many of which are lost during the milling and polishing process. Rice fortification may be considered as having the highest potential to fill the gap in current staple food fortification programs as it is the staple food of 65 percent of the Indian population and reaches the most vulnerable and poorer section - with the highest uptake in the government safety net programs.

Fortification is the process of adding Fortified Rice Kernels (FRK), containing FSSAI prescribed micronutrients (Iron, Folic Acid, Vitamin B12) to normal Rice (Custom Milled Rice) in the ratio of 1:100 (Mixing 1 Kg of FRK with 100 Kg custom milled rice). Fortified rice is nearly identical to traditional rice in aroma, taste, and texture. This process is done in the rice mills at the time of milling of rice. At present (August 2022), there are more than 9000 rice mills in the country which have installed blending infrastructure for production of fortified rice and their cumulative monthly production capacity is around 60 LMT which is increased by more than 4 times since last year. Last year up to 15th August 2021 the number of rice mills having blending infrastructure was 2690 with cumulative blending capacity around 13.67 LMT.

Milk Fortification

National Action Plan for Dairy Development envisages to achieve milk production target of 254.5 Million MT by 2022 and 300 Million MT by 2023-24 from 155.5 Million MT during 2015-16 requiring an annual growth rate of 8.56% which would lead to increase in per capita availability of milk from current level of 337 grams per day to 515 grams per day by 2022 and 592 grams per day in 2023-24 addressing the substantial nutritional requirement of growing population in India. Vitamin A & D that are naturally present in milk are usually lost during processing. Therefore, several countries made a compulsion to add the lost vitamins as a means of replenishment of milk with nutrients (NDDB 2016).

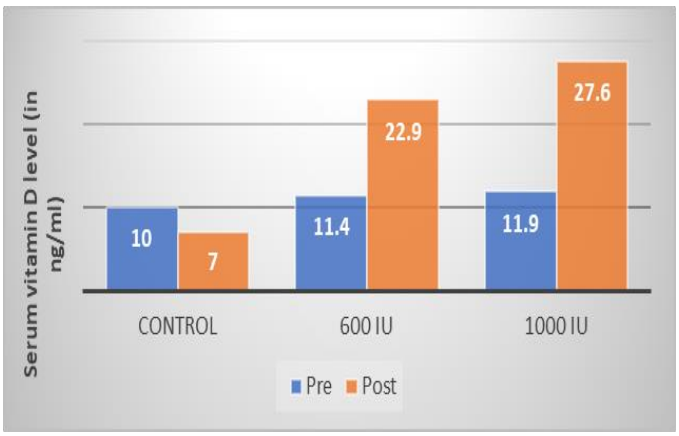

Fig. 1 Effect of milk fortification on vitamin D levels

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Studies have shown that the consumption of fortified milk by children in India have not only increased the serum vitamin D levels but also reduced morbidity rates. Fig 1 gives an idea about the effect of milk fortification on serum vitamin D levels.

The process of fortification is quite established, simple and cost effective. Vitamin A and vitamin D premixes are easily available worldwide at attractive prices. The cost of fortifying milk is nominal and therefore, fortification of milk with vitamin A & D in India is an efficient and effective way to reduce micronutrient deficiencies.

Edible oil fortification

Edible oil is also considered as a promising carrier for fortifying fat soluble vitamins such as vitamin A & D Around 1953, Vanaspati was fortified with vitamin A (FSSAI 2016). As per Household Consumer Expenditure (HCE) Survey in India, (NSSO report 2011), consumption of oil is reasonably high, about 20-30g / person / day and is consumed by all population groups. Since vitamin A and D are fat-soluble vitamins, fortification of edible oils and fats with vitamin A and D is a good strategy to address micronutrient malnutrition and fortified oil is known to provide 25%-30% of the recommended dietary allowances for vitamins A&D.

III. SUGAR AS POTENTIAL VEHICLE FOR FORTIFICATION

General perception of sugar by consumers and initiatives taken by F&B manufacturers

Sugar is one commodity which finds its application in numerous products as a sweetening agent & hence sugar occupies itself in every household shelves. Sugar has been a part of the human diet for centuries but has recently been the target of considerable media attention, particularly in relation to obesity, diabetes and overall health. Apart from providing a sweet profile to a product, it is often added to processed food so as to improve their palatability or to add texture or colour. Hence, the long ongoing debate relating to 'sugar & health' and the facts provided by media as sugar contributes towards calories and nothing else often fails to acknowledge the role of sucrose in the context of total diet. It is also worth mentioning that often food products made without sugar but by using other ingredients e.g. fats or starches may provide same amount or in some cases even more calories than sugar (IGD- Working Group Report 2010) (Reid M. and Hammersley R. 2014).

Studies by International Sugar Organization indicate that sugar is not the sole culprit for all the claimed health issues but this is largely attributed to sedentary life style, physical activity and imbalanced diet. Initiatives thus are required to be taken in a direction so as to remove such misconceptions about sugar intake. From a market point of view, the present market is driven by two forces that go along hand in hand. First, changing consumer behaviour, who are becoming healthy and more conscious with respect to what they consume resulting in the changes in their purchasing patterns. Secondly, the Food& Beverage industry which is trying its best to keep pace with the present demands of the consumers and also to keep themselves self-regulated and away from criticism (ISO 2016).

Sugar Consumption Patterns in India

A recent study provided by Indian sugars reveal swift change in sugar consumption across metropolitan cities viz. Mumbai and Ahmedabad. The report says that the average intake of 'added sugar' in all metropolitan cities is around 19.5 g/day which is considered to be below the ICMR recommended intake of 30 g/day. The report further says that the fraction of energy.

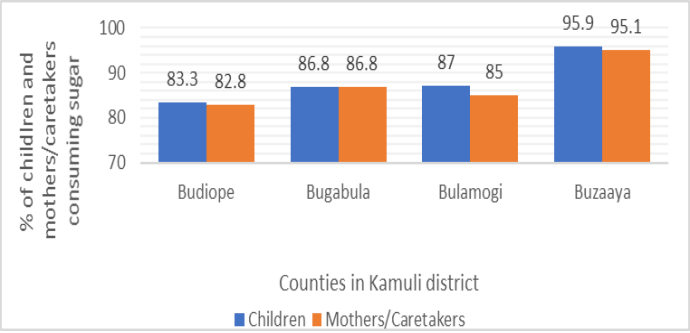

Fig. 2 levels of sugar consumption in 4 counties in Kamuli district

gained through added sugar as a part of total energy gained is around 5.1% only (Indian Sugar 2020). Therefore, blaming sugar alone for the added calorie gain may be troublesome as it deviates the attention and resources away from other factors that may cause excessive body weight such as poor eating habits, sedentary lifestyle, imbalance diet etc.

IV. HEALTHIER SUGAR - A WAY FORWARD

Going by the history of sugar fortification, around mid-1970s sugar fortification was first taken up in some countries in Central America and a national programme in three countries, Guatemala, Honduras and Costa Rica was established with a view to reduce vitamin A deficiency (Oscar P., 1998). Such initiative paved way for improving the vitamin A profile among pre-schoolers. The cost of fortification was around US$ 9.18 (INR 596.7) per MT (@industry front) which was around US$ 0.20/year (INR 13) per person. Other countries in Latin America are now implementing vitamin A fortification programme as detailed in table 1. Asian countries viz. Philippines are on the way to adapt sugar fortification programme so as to combat the deficiency. Likewise, Zambia in around 1990 showed efforts to fight vitamin A deficiency through sugar fortification. In 1999 Kalungwishi Estate in Zambia initiated sugar fortification programme. The fortified sugar was produced for sale purpose only (John A. Serlemitsos Harmony Fusco 1998–2002). However, the fortification cost was high for Kalungwishi Estates as the scale of operation was smaller.

A study was conducted in the Kamuli District of Uganda where sugar was assessed as the potential vehicle for vitamin A fortification. In this pilot study, fifty mothers/caretakers in households with one or more children aged 12 - 36 months were interviewed from each of the four counties of Kamuli

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district namely Budiope, Bugabula, Bulamogi and Buzaaya. The study aimed at determining the frequency of consumption of each of the following foods: maize meal, cooking oil, salt and sugar. On a semi-quantitative basis, it was observed that maize meal was consumed by around 33% of the household, 17% cooking oil, 27% salt and 78% sugar. Since sugar had the major fraction in consumption among other household goods, the study was taken up to evaluate whether sugar could be a possible vehicle for fortification of vitamin A. the outcome of the study was however quiet promising. It was found that more that 80% of all children in each of the selected 4 areas (Budiope, Bugabula, Bulamogi and Buzaaya) consumed sugar on a daily basis.

Fortification Rapid Assessment Guidelines and Tool (FRAT) recommends that if a food is consumed by at least 50% of the sample population of children between 12 - 36 months in the last 7 days, it is most likely that fortifying such a food will be an effective public health intervention for the entire region sampled. Therefore, sugar fortification with vitamin A might be an effective way of combating vitamin A deficiency in Kamuli district (Medi K., 2002).

While analysing the above data on the initiatives taken towards enhancing the nutritional profile of every individual, it is pertinent to mention that sugar which is being consumed by almost every individual, forms a part of the human diet for centuries and serves as an important source of energy for people across the globe, could serve as one of the potential vehicle for fortification towards the existing initiatives with the aim of providing healthy lifestyle and also curtailing the prevalence of micronutrient deficiency across the country. Since in India, sugar is yet not exploited to its fullest potential, this step of fortifying sugar would help the country's end all forms of malnutrition by 2030' goals and also simultaneously uplifting the sugar sector as a whole (Ezzati et. al., 2004).

Fig. 3: Global fortified sugar market

To back up this thought, a recent report published by 'Market Persistent' elaborates on the market potential of market potential of fortified sugar at a global perspective. The report states that more than US$ 9.6 billion worth of fortified sugar would be the highlight of the market shelf and would be sold by the end of the forecasted period 2017-26. It is expected that during this forecasted period the global market for fortified sugar would expand at a 5.1% CAGR as evident from Fig.3.

As mentioned above, sugar manufacturers could be the driving force and helping strengthen the nutritional profile of its consumers by initiative such as enriching sugar with nutrients. Furthermore, with increasing incidences of recorded nutritional deficiency, governments in several economies are enacting norms for fortification of sugar (Persistent Market Research, 2018).

V. REASONS FOR FORTIFYING HOUSEHOLD SUGAR

1. Sugar processing is centralized thereby creates a greater opportunity for proper quality control and hygienic manufacturing of such high profile product.
2. Sugar is consumed by a major fraction of the population thereby no additional changes in the dietary patterns of the individual are required.
3. Reasonable prices of sugar are also an attractive point for opting sugar fortification as the product is within the reach of every individual.
4. The wide use of sugar in children's food such as porridge and bakery items.
5. Efficient distribution system.
6. Better binding characteristics than other potential target foods (Guillermo A. and Omar D., 1992-1994).

VI. ENVISAGED FORTIFICATION CRITERION

To begin with possibilities of raw sugar fortification with vitamin A are to be explored. The main objective of fortification of sugar with vitamin A is to make sure that the basic requirements of vitamin A are met for all group of people particularly, the ones at greater risk of deficiency without increasing the average intake of sugar by individuals. The levels of vitamin A that must be added to sugar are to be determined by recommended dietary allowance (RDA) of the vitamin A by every individual and the sugar consumption pattern as per different age groups. As per the report published by FSSAI in regards to the RDA of vitamins and minerals by different age group, children under the age of 6 are more vulnerable to vitamin A deficiency, the RDA requirement is around 400 µg RE (1330 IU) per day. Pregnant women are also at high risk of vitamin A deficiency; their RDA requirement is around 800 µg RE (2664 IU) (WHO 1998).

VII. PROCESS TECHNOLOGY

The process involved in sugar fortification in countries which adopted sugar fortification is based on premix preparation which contains higher concentration of vitamin A. The prepared premix is then blended with bulk sugar, packed and marketed. The premix is prepared by mixing sugar with the requisite quantity of vitamin in a blender (V-type). The blender is provided with spray nozzles which allow the antioxidant-oil mixture to be added during the mixing operation. After proper mixing of the premix in the blender for 20-30 minutes, the sugar is packed in 25 kg bags or other consumer packs (Oscar P., 1998). The points of adding premix during sugar processing may vary and one such system may be as illustrated in Fig 4.

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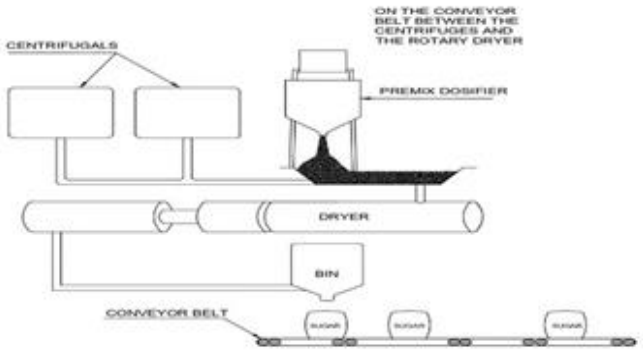

Fig 4: Possible points for premix addition during sugar processing

However, with industrial revolution, technological advancement and process efficiencies have taken all new different heights. Innovations in the field of sugar processing and packaging have paved way for value-addition in a new improved and cost effective manner. New and advanced methods in processing, packaging and distribution system could help improve fortification of sugar with increased shelf life and making it available in consumer & environment friendly packaging.

VIII. INNOVATION – A WAY FORWARD

Sugar fortification through co-crystallization technique could be an excellent way of enhancing the nutritional profile and felicitating sugar industry to expand its product profile in both national and international market. Sugar being an essential commodity and also being consumed by individual serves as a promising carrier for fortification of essential nutrients. This initiative would not only help improving the nutritional aspect of the society but would also help fulfilling the basic RDA (recommended dietary allowance) requirement of individuals which may not be achievable through normal diet. The estimated cost of fortification of sugar through co-crystallization may be around 5-7% higher than the conventional plantation white sugar (@ industry front). Various other initiatives keeping in mind the safety and quality aspect of sugar may be adopted for an outstanding product profile ideal for the health conscious consumers and to mitigate the problem of nutrient deficiency. Controlled atmospheric packaging or nitrogen infusion along with use of laminate packing for packaging of fortified sugar may go a long way in enhancing the shelf life of the product and greater acceptability amongst consumers as well.

IX. CONCLUSION

Sugar is an essential ingredient of daily diet and as far as India is concerned, it comes under 'Essential Commodity Act'. Sugar, thus can be a potential carrier for fortification of various essential nutrients including vitamin A. Considering growing campaign about ill health effects of sugar, thought process to be developed for enhancing the nutritional profile of it. While, aggressive marketing including media campaign is required to remove myth but not looking to the changing market requirements and consumer preferences, sugar is to be developed and marketed as nutritious product. As regards, sugar fortification with vitamin A and other nutrients, technological advancements are to be made to prolong the shelf life of the product with maximum retention of the nutrients in sugar.

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